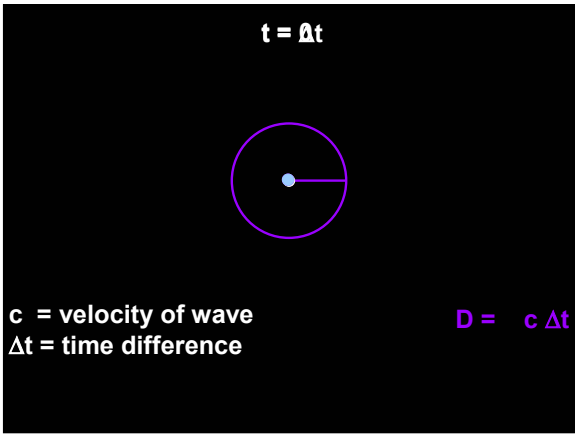
NS 102 Lecture 12 May 10, 2005

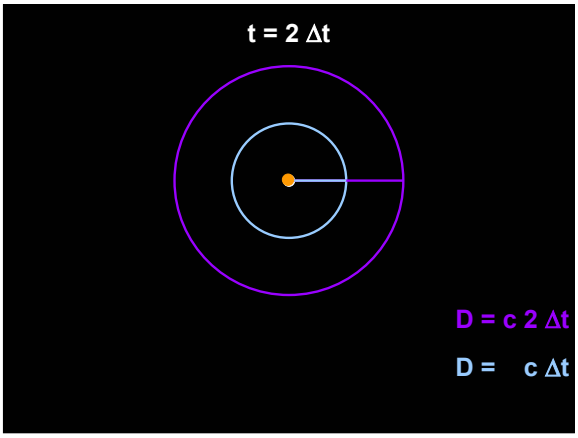
Open: Eisley – "Plenty of Paper"
Close: Jimi Hendrix – "Third Stone from the Sun"

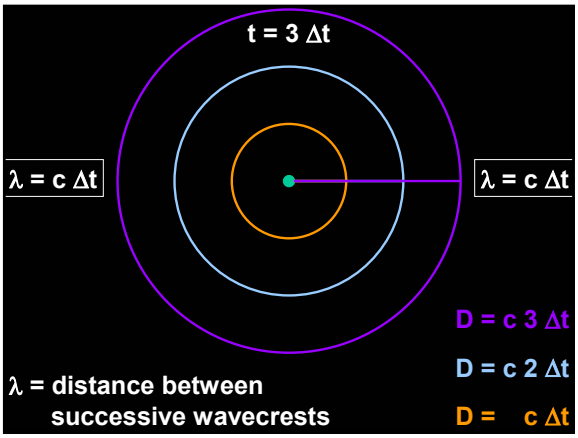
GnatSigh News
(all the news that fits)

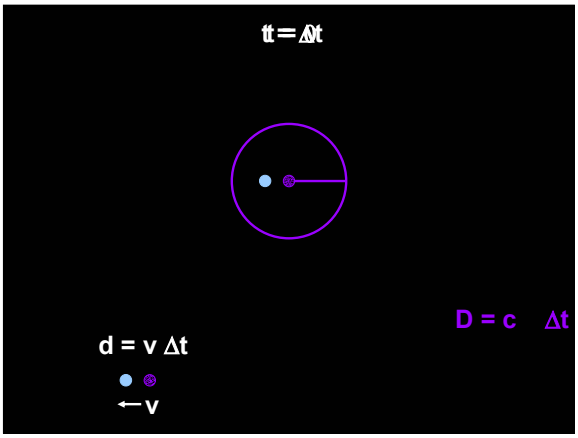
- Website http://home.fnal.gov/~rocky/NS102/
- Shapley-Curtis information at http://antwrp.gsfc.nasa.gov/diamond_jubilee/debate.html
- Messier Objects http://www.seds.org/messier/
- Well tempered http://www.bachfaq1.orgf/welltemp.html
- Today: Concert "Car horn in $A^{\flat}$"
- Thursday: The death of Elvis

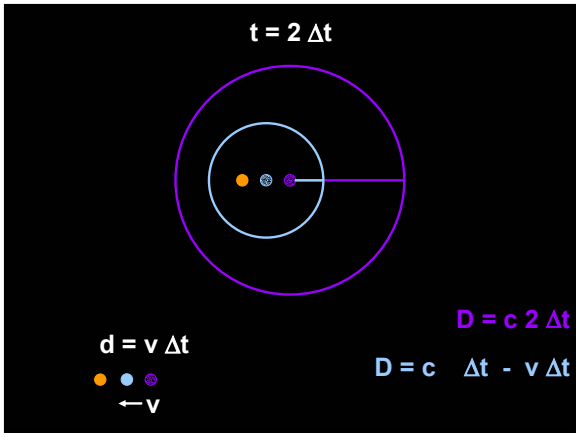
Lab this week: Geometry of the Universe

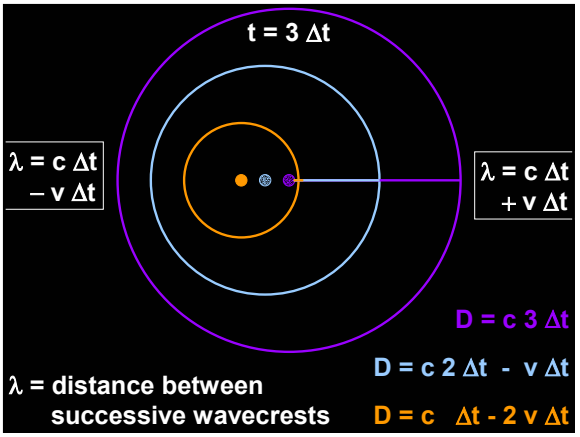












Doppler Shift

$\lambda_0 = c\Delta t =$ rest wavelength

$\lambda = c\,\Delta t \pm \mathrm{v}\,\Delta t =$ detected wavelength

$$c\,\Delta t = \lambda_0 \quad \Rightarrow \quad \lambda = \lambda_0 \pm \mathrm{v}\,\Delta t$$

$$\Delta t = \frac{\lambda_0}{c} \quad \Rightarrow \quad \lambda = \lambda_0 \pm \frac{\mathrm{v}}{c}\lambda_0$$

$$\boxed{\lambda = \lambda_0\left(1 \pm \frac{\mathrm{v}}{c}\right)}$$

+ → receding (longer λ)
– → approaching (shorter λ)

Frequency

$\frac{1}{\Delta t} \equiv$ frequency $= \nu$ (nu)

(usually measured in Hz = s^{-1})

$$c\,\Delta t = \lambda \Rightarrow c = \frac{\lambda}{\Delta t} \Rightarrow c = \lambda\nu$$

$$c = \lambda\nu$$

velocity = wavelength × frequency

$$\frac{\mathrm{cm}}{\mathrm{s}} = \mathrm{cm} \times \mathrm{s}^{-1}$$

Doppler Shift

$\lambda_0 =$ emitted wavelength

$\lambda =$ detected wavelength

$$\lambda = \frac{\mathrm{c}}{\nu} \Rightarrow \lambda \propto \frac{1}{\nu}$$

$$\boxed{\lambda = \lambda_0\left(1 \pm \frac{\mathrm{v}}{c}\right)}$$

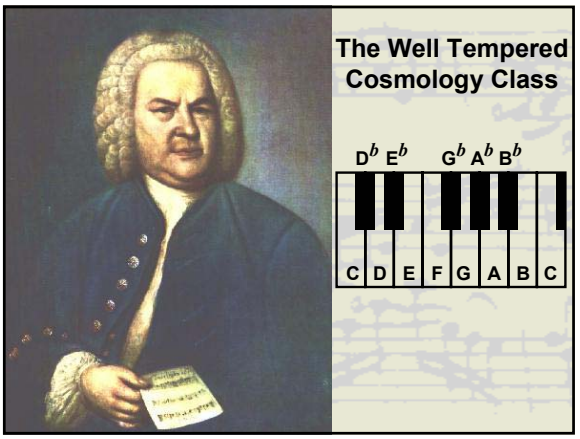
+ → receding (longer λ)
– → approaching (shorter λ)

$$\boxed{\frac{c}{\nu} = \frac{c}{\nu_0}\left(1 \pm \frac{\mathrm{v}}{c}\right)}$$

+ → receding (longer λ)
– → approaching (shorter λ)

$$\boxed{\nu = \frac{\nu_0}{1 \pm \frac{\mathrm{v}}{c}}}$$

+ → receding (smaller ν)
– → approaching (longer ν)



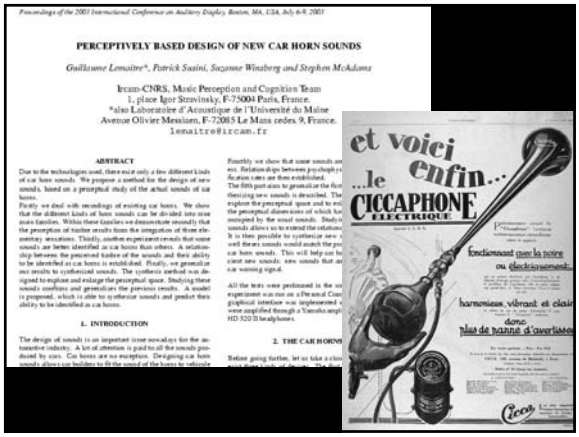
262	277	294	311	330	349	370	392	415	440	466	494	523
C	D^b	D	E^b	E	F	G^b	G	A^b	A	B^b	B	C
1	a	a^2	a^3	a^4	a^5	a^6	a^7	a^8	a^9	a^{10}	a^{11}	a^{12}

Frequency increase by a factor of 2

$a^{12} = 2 \quad a = 1.05946$

$$\frac{\lambda}{\lambda_0} = 1 \pm \frac{v}{c} \qquad v = 70 \text{ mph} \qquad c = 700 \text{ mph} \qquad \frac{v}{c} = 0.1 \qquad \frac{\lambda}{\lambda_0} = \begin{cases} 1.1 \\ 0.9 \end{cases}$$

$$\frac{\nu}{\nu_0} = \frac{\lambda_0}{\lambda} = \begin{cases} 0.9 \\ 1.1 \end{cases}$$



PERCEPTIVELY BASED DESIGN OF NEW CAR HORN SOUNDS

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ABSTRACT

1. INTRODUCTION

2. THE CAR HORNS

262	277	294	311	330	349	370	392	415	440	466	494	523
C	D^b	D	E^b	E	F	G^b	G	A^b	A	B^b	B	C
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$$\frac{\nu}{\nu_0} = \frac{\lambda_0}{\lambda} = \begin{cases} 0.9 \\ 1.1 \end{cases}$$

$\nu_0 = 415 \text{ Hz} \quad A^b$

$$\nu = \begin{cases} 370 \text{ Hz } G^b \\ 466 \text{ Hz } B^b \end{cases}$$

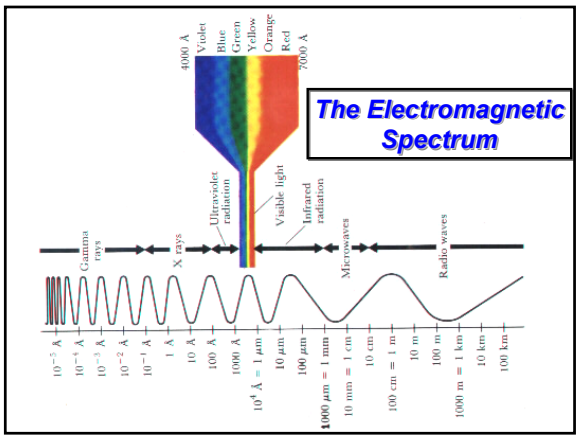
World Premiere

Car Horn in A^b

Sonata for Violin

New composition by
Maestro Rocky Kolb

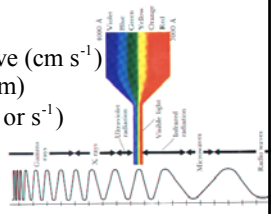
Performed by
Vanessa Tantillo, violin

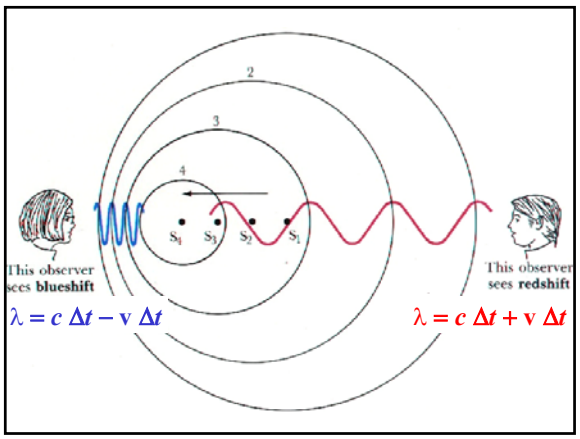


Facts about light

1. Light is a wave

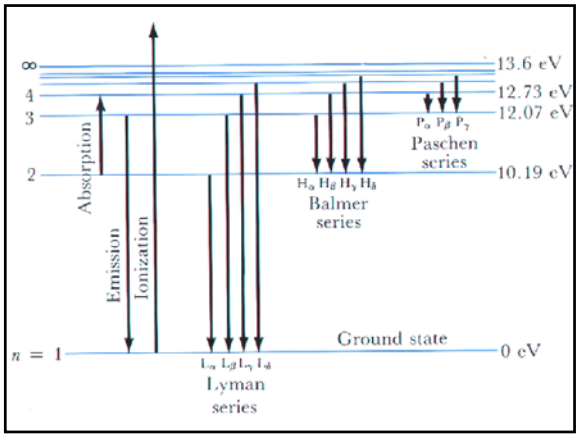
$c = \lambda \nu$ $\begin{cases} c = \text{ velocity of wave (cm s}^{-1}) \\ \lambda = \text{ wavelength (cm)} \\ \nu = \text{ frequency (Hz or s}^{-1}) \end{cases}$





Nothing exists but atoms and empty space; everything else is opinion.
- Demokritos

Everything has been thought of before. The problem is to think of it again.
- Goethe



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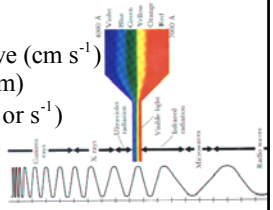
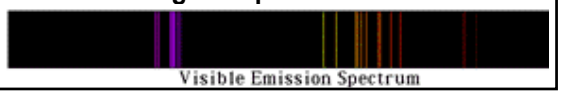
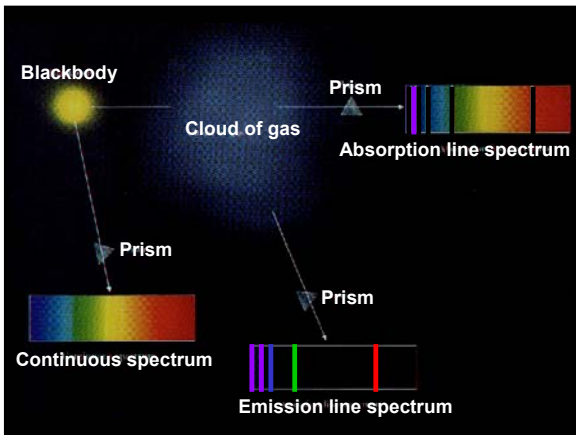
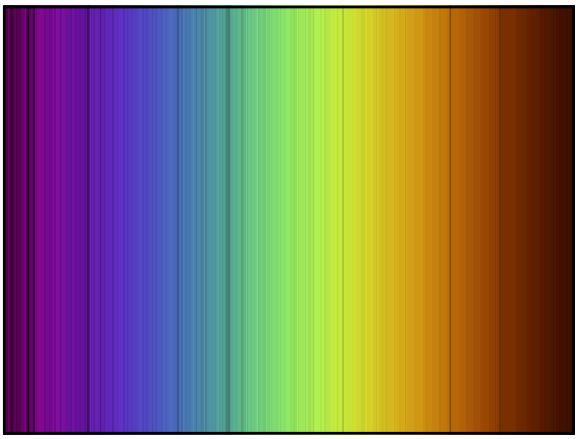
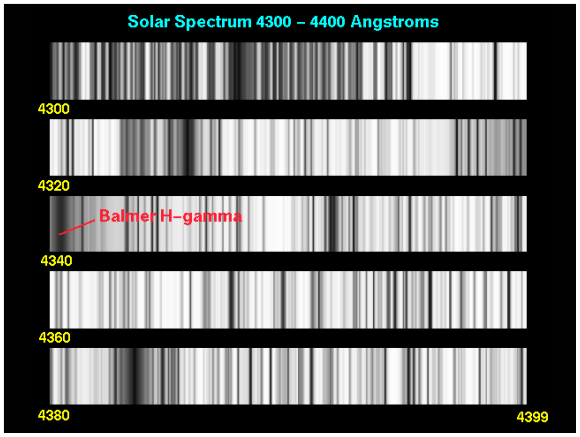


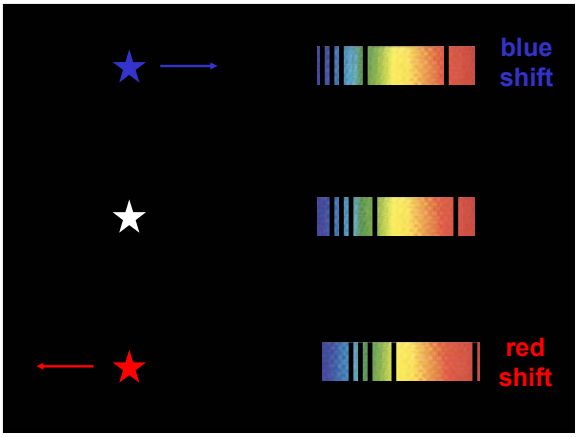
2. The wavelength is quantized

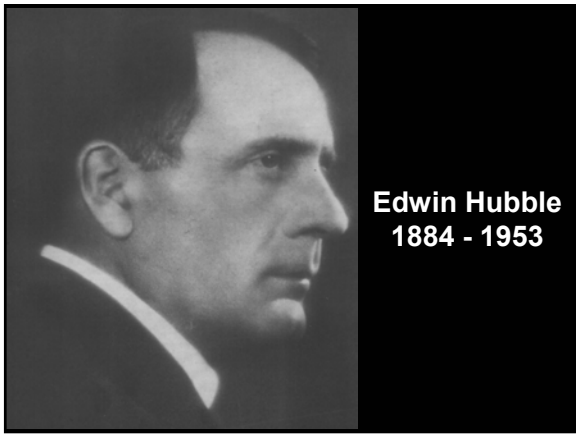












The **red shift**

$$\frac{\lambda}{\lambda_0} = 1 + \frac{v}{c}$$

λ detected wavelength

λ_0 emitted wavelength

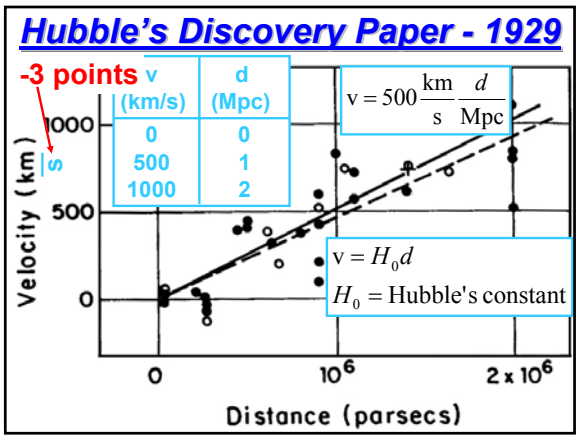
v recessional velocity

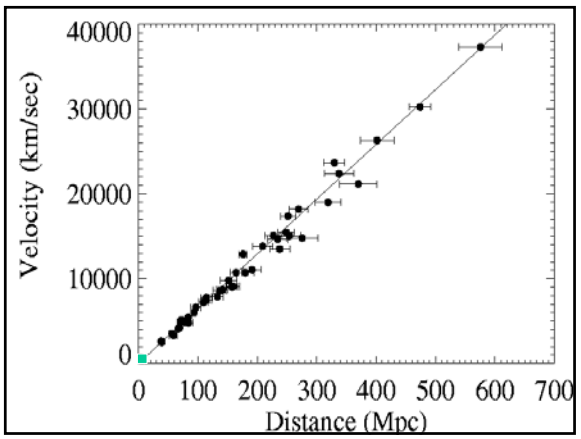
c velocity of light

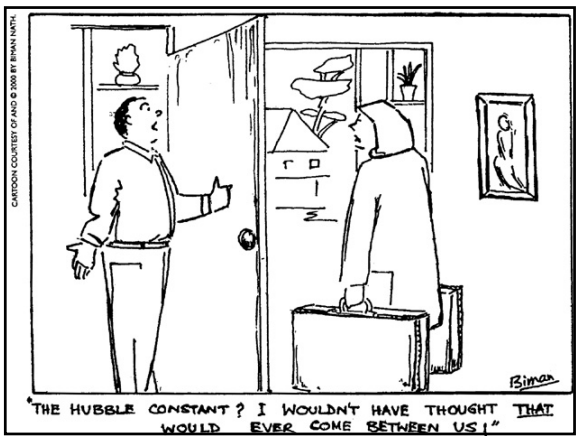
$$\frac{\lambda}{\lambda_0} - 1 = \frac{v}{c}$$

$c = 3 \times 10^5$ km s^{-1}

$(\lambda > \lambda_0)$



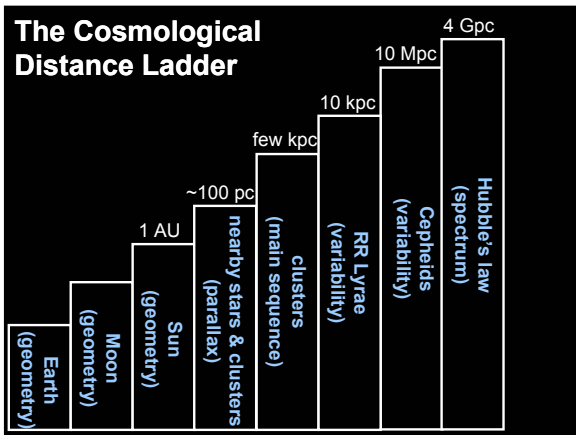




$v = H_0 d$

H_0 = Hubble's constant

$H_0 = 500$ km s^{-1} Mpc^{-1}	**Hubble**	**1929**
$H_0 = 100$ km s^{-1} Mpc^{-1}		**1960s**
$H_0 = 55$ km s^{-1} Mpc^{-1}		**1970s**
$H_0 = 65$ km s^{-1} Mpc^{-1}		**1990s**
$H_0 = 72$ km s^{-1} Mpc^{-1}		**2001**



$v = H_0 d$

H_0 = Hubble's constant

Let's assume $H_0 = 100$ km s^{-1} Mpc^{-1}

$$v = 100 \frac{\text{km}}{\text{s}} \frac{d}{\text{Mpc}}$$

v	d
100 km s^{-1}	1 Mpc
1,000 km s^{-1}	10 Mpc
10,000 km s^{-1}	100 Mpc
100,000 km s^{-1}	1,000 Mpc

$$\lambda = 6,000 \text{ Angstroms}$$

$$\lambda_0 = 5,000 \text{ Angstroms}$$

$$\frac{\mathrm{v}}{c} = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{1000}{5000} = 0.2$$

$$\mathrm{v} = 0.2c \implies \mathrm{v} = 60{,}000 \text{ km s}^{-1}$$